Worthington, whose name, however, is nowhere mentioned. "These kinetic examples of the action of heat must not be expected to simplify the theory, except in so far as they give the mind something definite to grasp; what they do is to substitute something we can see for what we can barely conceive."

The Mass Formula of Cathode-ray Corpuscles.

Vérification expérimentale de la formule de Lorentz-Einstein. Par Prof. Ch.-Eug. Guye, en collaboration successive avec S. Ratnowsky et Ch. Lavanchy. (Mémoires de la Société de Physique et d'Histoire naturelle de Genève, vol. 39, fasc. 6.) Pp. 273–364 + plates 4–6. (Genève: Muséum d'Histoire naturelle, 1921.) 20 francs.

THIS memoir gives a detailed account of experiments made by MM. Guye and Ratnowsky in 1907–9, and by MM. Guye and Lavanchy in 1911–13, with the object of testing the mass-formulæ of Abraham and of Lorentz for the cathode-ray corpuscles. Preliminary notices of these researches have appeared from time to time, but now they are published in their final form, preceded by a theoretical and historical introduction of twenty pages, whilst twenty pages are devoted to the experiments of Guye and Ratnowsky, and forty pages to those of Guye and Lavanchy; the whole concludes with a small collection of tables and plates. There are records of twenty-seven experiments by Guye and Ratnowsky for the range from $\beta = 0{\cdot}21$ to $\beta = 0{\cdot}59$, and of 151 experiments by Guye and Lavanchy from $\beta = 0{\cdot}25$ to $\beta = 0{\cdot}49$. The first series of experiments gives for the excess of the observed mass of the electron above the Lorentz mass a mean value of five thousandths, and for that above the Abraham mass a mean value of nineteen thousandths, with a probable error of about three thousandths; the second gives for the same quantities two ten-thousandths, eleven thousandths, and one two-thousandth respectively. Thus the evidence of these investigations is strongly in favour of the Lorentz mass formula, in complete agreement with previous researches of similar rank, such as those of Bucherer, Wolz, and Neumann on β-rays, and of Hupka on accelerated photo-electrons.

Like Hupka, Guye and his associates used a relative method; the electric or magnetic force, as the case happened to be, which was required in order to produce a prescribed deflection of a given fast cathode-ray pencil, was compared with that needed to produce an equal deflection of a slow cathode-ray pencil selected as a standard. But whilst Hupka used only the magnetic deflection and relied for the determination of the speed of his photo-electrons on the measurement of the vacuum tube potential employed in accelerating them, Guye and his associates used both the electrostatic and magnetic deflections, not simultaneously, as had been the usual previous practice, but separately and alternately. Thus they eliminated errors due to variations in the state of the vacuum tube, rejecting *ab initio* all experiments in which sudden changes in its condition were suspected. They avoided the large errors which are almost inseparable from the measurement of very high potentials (of the order of 80,000 volts), which completely vitiated Hupka's results, at any rate according to Heil's criticism of his experiments.

The relative method, or method of "identical trajectories," as Guye and his associates call it, has the advantage of not requiring an exact knowledge of the distribution of the electric and magnetic forces, which, especially for the electric field, is very difficult to determine with sufficient accuracy. Since the speed of an electron is not altered by a magnetic field, we can for two cathode-ray pencils of different speeds make the terminal deflections equal by a proper choice of the ratio of the magnetic forces at corresponding points, and so ensure that the trajectories are identical throughout; then the electro-magnetic momenta (transverse mass × speed) will be in the ratio of the magnetic forces—*i.e.* of the electric currents generating the field. But for the electric field the equality of the terminal deflections of two cathode-ray pencils of widely different speeds does not guarantee the identity of their trajectories, if only because the electric field generally alters the speed. In the experiments of Guye and his associates the changes of speed produced amounted to only a few thousandths of the whole, so that the trajectories were very nearly identical, and the error arising from this cause was negligible. Consequently for two cathode-ray pencils of widely different speeds undergoing equal electrostatic deflections the products of their transverse masses into the squares of their speeds could be taken to be in the ratio of the deflecting electric forces—*i.e.* of the differences of the potential between the plates of the condenser used to produce the deflection. Thus the ratios of the speeds and of the transverse masses of the two cathode-ray pencils could be expressed in terms of the measured ratios of the currents in the magnetising coils and the potential differences of the condenser. In this way the speeds and masses of a number of cathode-ray pencils of various high speeds were compared with those of a pencil of a standard low speed, without the need of finding the distribution of the electric or magnetic fields or the discharge potentials for the high-speed pencils.

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In order to test the mass formulæ the speed and mass of the slow-speed pencil were found by measuring the discharge potential directly with an electrometer, which could be effected with sufficient accuracy, because in this case the difference of potential was only about 14,000 volts. The speed ($\beta = 0{\cdot}228$) was calculated by successive approximation, the appropriate mass formula being employed to estimate the necessary correction to the zero mass, which for this low speed amounted to only 3 per cent. The result, together with the measured electrostatic deflection, supplied the data needed for the evaluation of the electric field integral, which was used in the comparison with the high-speed cathode-ray pencils. In the earlier experiments this field integral was also evaluated by graphic calculation from the constants of the condenser, but the experimental method of determination was adopted finally as more accurate, the difference between the two methods being about 5 per cent. In the later experiments curved condenser plates were used, in order to render the trajectories more nearly equipotential; in this case graphic calculation was impossible. No data are given for the magnetic field integral, perhaps because it was always eliminated; nevertheless, its evaluation from the constants of the apparatus might have been useful as a check, and would have made the direct calculation of the magnetic deflection possible, with a view to meeting beforehand Heil's objection to Hupka's use of the relative method, viz. that the observed magnetic deflections differed widely from those calculated from the measured currents and the constants of the apparatus.

Apart from the absence of this check, every precaution seems to have been taken to ensure accuracy; the earth's magnetic field was compensated, electrostatic influences were guarded against, special arrangements were used to secure regular working of the vacuum tube, and the number of observations was amply sufficient to eliminate practically all accidental errors. The authors are to be congratulated on producing a most valuable contribution to our knowledge of the dynamics of the electron.

British University Problems.

Second Congress of the Universities of the Empire, 1921: *Report of Proceedings.* Edited by Dr. Alex. Hill. Pp. liv+452. (London: Published for the Universities Bureau of the British Empire by G. Bell and Sons, Ltd., 1921.) 21*s.* net.

THE Report of the Proceedings of the Second Congress of the Universities of the Empire held at Oxford on July 5–8, 1921, has just been published as a volume of more than five hundred pages. It will be recalled that the first of these Congresses was held in 1912, and, but for the intervention of the war, would have been followed by the second in 1917. Fifty-nine universities—six more than in 1912—sent upwards of three hundred delegates and representatives to it. The main topics under discussion were the balance of studies; the teaching of civics, politics, and social economics; secondary education; adult education; technological education; the training for commerce, industry, and administration; the training of school teachers; finance; research; and the interchange of teachers and students—all, of course, with reference to the universities. Such a varied and comprehensive programme required some skill in arranging and handling, and Dr. Hill is to be congratulated on the way he has edited the Report.

Thirty-five papers were presented to the Congress. These have been printed *in extenso,* together with verbatim records of the discussions which followed. Though lack of space prevents it, a mere list of the names of the various speakers would be interesting in itself, as giving a list of distinguished scholars drawn from all quarters of the British Empire. For such particulars, reference must be made to the Report itself. The opening address was given by Lord Curzon, the Chancellor of the University of Oxford, who welcomed the Congress to Oxford, and expressed his opinion of the value of such Congresses as having it in their "power to play a very important part in developing the organisation and drawing closer the bonds of the British Empire." This was followed by an able paper on "The Present and the Future of Hellenism." Unfortunately, the discussion was limited, no doubt, by the fact that it was followed by four other papers in immediate succession. Sir A. J. Balfour, the Chancellor of the Universities of Cambridge and Edinburgh, who presided at the discussion on "The Universities and the Teaching of Civics, Politics, and Social Economics," in his opening speech raised the question of innate differences of races among human beings, but decided, very wisely, not "to wander into a topic so tremendous." In the general discussion, the point that "only a few boys in any school can go to the university" was raised, and, curiously enough, was emphasised in a paper which followed dealing with the question of the university and secondary education. The same point came up in another form, when Lord Haldane, in a notable address on adult education, referred to the extent to which the universities were dependent on the taxes and rates. "Democracy," he said, "is beginning to ask why it is that, while they pay the rates and taxes, only a limited section of society gets

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